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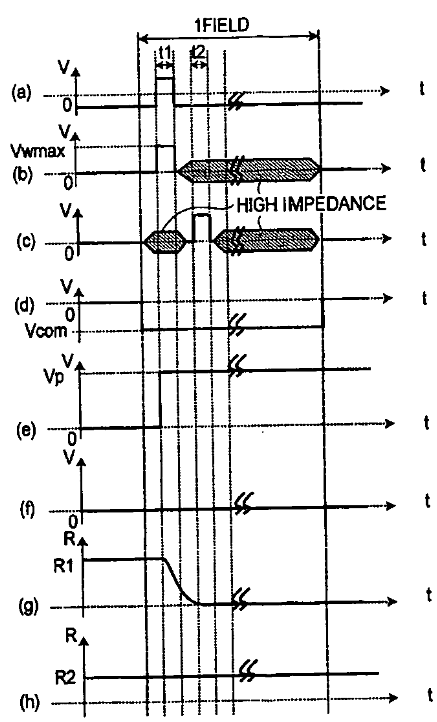
(54) Title: DISPLAY APPARATUS WITH INPUT PEN FOR WEARABLE PC



(57) Abstract: An electrophoretic display apparatus or a ferroelectric liquid crystal display apparatus includes a display panel 10 including gate line electrodes 33 and source line electrodes 34 arranged in a matrix to provide a multiplicity of pixels at respective intersections of these electrodes, a gate line drive circuit 213 for driving the gate line electrodes 33, and a source line drive circuit 212 for driving the source line electrodes 34. When a display state of the display panel 10 is partially rewritten, a reference voltage of a common electrode 37 is switched to a negative voltage Vcom on the basis of 0 V which is a reference voltage at the time of multi-gradation level display. As a result, the display apparatus can be driven at a high voltage to permit high-speed rewriting of the display panel, so that a display response characteristic in writing of white/black binary data or black writing by pen input is improved.

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DESCRIPTION

DISPLAY APPARATUS WITH INPUT PEN FOR WEARABLE PC

[TECHNICAL FIELD]

The present invention relates to a display apparatus including a display panel having a multitude of pixels arranged in a matrix.

[BACKGROUND ART]

With development of information equipment, the needs for low-power and thin display apparatuses having grown, so that extensive study and development have been made on display apparatuses fitted to these needs.

Such a display apparatus is used frequently outdoors particularly as a wearable PC (personal computer) or an electronic note pad, thus being desirable that it can save power consumption and space. For this reason, e.g., such a product that a display function of a thin display such as a liquid crystal display and means for inputting coordinate data are integrated, and direct input can be effected by pressing a display item on a display surface with a stylus or finger, has been commercialized.

However, most of liquid crystal materials have no memory characteristic, so that it is necessary to

continuously apply a voltage to the liquid crystal during a display period. On the other hand, a liquid crystal material having a memory function cannot readily ensure a reliability in the case of assuming its use in various environments such as outdoor environment as in the wearable PC, thus failing to be put into practical use.

In view of these circumstances, as one of thin and light display apparatuses, an electrophoretic display apparatus has been proposed (U.S. Patent No. 3,612,758).

This type of electrophoretic display apparatus includes a pair of substrates disposed with a predetermined spacing therebetween, an insulating liquid filled in the spacing, a multiplicity of colored charged (migration) particles dispersed in the insulating liquid, and display electrodes disposed at each pixel along each substrate.

In this electrophoretic display apparatus, the colored charged particles are electrically charged positively or negatively, so that they are adsorbed by either one of the display electrodes depending on a polarity of a voltage applied to the display electrodes. As a result, e.g., it becomes possible to display various images by controlling a state in which the colored charged particles are adsorbed by the upper electrode and are observed from a viewer side

and a state in which the colored charged particles are adsorbed by the lower electrode, so that the color of the insulating liquid is visually identified. This type of the electrophoretic display apparatus is referred to as a vertical movement type electrophoretic display apparatus.

As another example of a conventional electrophoretic display apparatus, Japanese Laid-Open Patent Application (JP-A) No. Hei 9-211499 discloses such an electrophoretic display apparatus, different from the above described vertical movement type electrophoretic display apparatus in which the insulating liquid is sandwiched between the upper and lower electrodes, that a first electrode (common electrode) is disposed along a light-blocking layer located between adjacent pixels and second electrode (pixel electrode) is disposed over an entire pixel display portion and is covered with an insulating film.

For this reason, an insulating liquid is only required to be transparent, so that the display apparatus effects black display by covering the second electrode with electrophoretic particles and effects white display by collecting the electrophoretic particles to the first electrodes located between adjacent pixels to expose the second electrodes. As a result, by controlling a polarity of applied voltage pixel by pixels, it is possible to effect display of

an image.

Further, by using these display apparatuses and a so-called resistance film type coordinate position detection apparatus (digitizer) in combination it becomes possible to effect pen input or input by manual pressure sensing thereby to realize a paper like display apparatus which, e.g., permits the wearable PC of power and space saving type and can take notes.

However, the above described conventional electrophoretic display apparatuses generally have a low response speed, so that, e.g., in the case where high-speed response for pen input is required, a user feels inconformity due to the low response speed.

In order to solve this problem, it can be considered that the electrophoretic display apparatus described above is driven at a high voltage. In the case of simply performing high-voltage drive, e.g., it can be considered that the display apparatus is provided with high voltage drive ICs or high voltage TFTs (thin film transistors). However, these high voltage driver ICs or TFTs have been accompanied with problems such that they cause a large packaging scale and a high-cost structure.

[DISCLOSURE OF THE INVENTION]

The present invention has accomplished for

solving the above described problems.

An object of the present invention is to provide a display apparatus capable of being driven at a high voltage while suppressing increases in packaging scale and production costs.

Another object of the present invention is to provide a display apparatus having a high-speed display response characteristic.

According to an aspect of the present invention, there is provided a display apparatus, comprising: a display panel including pixels arranged in a matrix; pixel electrodes provided to the pixels, respectively, and a common electrode provided common to the pixels; scanning lines and signal lines for supplying a voltage to the pixel electrodes; a drive circuit connected to the common electrode, the scanning lines, and the signal lines; and a control circuit for providing a signal to the drive circuit. The control circuit selectively switches a display drive mode in which the display apparatus displays an image on the display panel through sequential scanning of the scanning lines and application of a variable voltage to pixels via the signal lines by the drive circuit and a rewriting drive mode in which the display apparatus rewrites a part of pixels into black or white through application of a voltage, which is higher than a range of the variable voltage, to the

part of pixels on a scanning line selected by the drive circuit.

In the display apparatus, the drive circuit may preferably selectively scans only a part of the scanning lines in the rewriting drive mode. In a further preferred embodiments, in the display drive mode, the drive circuit supplies a variable voltage to the pixel electrodes and a reference voltage to the common electrode, and in the rewriting drive mode, the drive circuit supplies the voltage higher than the range of the variable voltage to a pixel electrode of pixels to be rewritten, places a pixel electrode not to be rewritten in a high-impedance state, and supplies to the common electrode a voltage which is shifted from the reference voltage to an opposite-polarity side of the voltage supplied to the pixel electrode of pixels to be rewritten.

The display apparatus may further comprises an external input device, and when the display apparatus receives display information from a device other than the external input device, the control circuit selects the display drive mode to execute display of the display information on the display panel, and when the display apparatus received display information from the external input device, the control circuit selects the rewriting drive mode to execute display of the display information received from the external input

device.

The external input device may preferably be a position information input device superposed on the display panel, a pen input device or a handwriting input device.

The display apparatus may preferably be an electrophoretic display apparatus or a liquid crystal display apparatus.

According to another aspect of the present invention, there is provided an input apparatus, comprising: a display panel including pixels arranged in a matrix; pixel electrodes provided to the pixels, respectively, and a common electrode provided common to the pixels; scanning lines and signal lines for supplying a voltage to the pixel electrodes; a drive circuit connected to the common electrode, the scanning lines, and the signal lines; a control circuit for providing a signal to the drive circuit; and a position detection device for detecting a position designated by a pointing member, such as a pen, and outputting information on the detected position. When there is no output of the position detection device, the control circuit selects a display drive mode in which a gradation image is displayed on the display panel and the drive circuit applies a variable voltage to pixels through the scanning and data lines to display the gradation image

on the display panel, and when there is an output of the position detection device, the control circuit selects a rewriting drive mode in which a part of pixels of the display panel is rewritten into black or white and the drive circuit scans a part of the scanning lines and applies a voltage, which is higher than a range of the variable voltage, to a part of pixels to rewrite the part of pixels corresponding to the position designated by the pointing member.

These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

[BRIEF DESCRIPTION OF THE DRAWINGS]

Figures 1(a) to 1(h) are timing charts for illustrating various signal waveforms and optical responses in an embodiment of the display apparatus according to the present invention.

Figure 2 is a system block diagram of the display apparatus of the present invention.

Figure 3 is a schematic view showing an TFT backplane of the display apparatus of the present invention.

Figures 4(a) and 4(b) are schematic views each

showing one pixel portion, including electrophoretic particles, of the display apparatus of the present invention.

Figures 5(a) and 5(b) are graphs each showing a relationship between a voltage and an optical response characteristic at a pixel in an embodiment of the present invention.

Figures 6(a) to 6(h) are timing charts for illustrating various signal waveforms and optical responses in another embodiment of the display apparatus of the present invention.

[BEST MODE FOR CARRYING TO THE INVENTION]

Hereinbelow, embodiments of the present invention will be described with reference to the drawings.

(Embodiment 1)

Figure 2 is a block diagram showing a display apparatus system having functions of still image display, pen input, and pen input display.

As shown in Figure 2, the display apparatus system includes: a display module 217 including a display panel 10 having a laminated structure of an electrophoretic display device 215 and a TFT substrate (backplane) 214, circuits 212 - 214 for matrix drive, and a common electrode drive circuit 216; a display control module 218; an image memory (SDRAM) 211 for

display; a CPU 28; and peripheral memory circuits including a flash ROM 29 and an SDRAM 210.

To the display control module 218, an external input device (sensing device) 27 is connected. The external input device is a device for inputting positional information, such as a pen input apparatus.

The CPU 28 supplies control signals to the display control module 218 and the peripheral circuit blacks 29 and 210.

In the display control module 218, a graphic controller 21 takes in information stored in the internal memories (the memory 29 constituted by the flash ROM and the memory 210 constituted by the SDRAM) and image information through an external memory control circuit (external I/F) 25 for controlling input and output of data with an unshown external memory, a communication means 24 for forming the data input and output via a circuit connected to an external circuit, or a digitizer controller 23 for controlling a pen input tablet 27 as the external input device (sensing device). Further, the graphic controller 21 stores information to be displayed on the display portion 215 of the display panel 10 in a Video RAM (VRAM) 211 on the basis of the image information and transfers image data and control signals to the display module 217 via a panel controller 22 on the basis of the information in the

VRAM 211. The graphic controller 21 further produces necessary control signals, such as scanning selection signals for selecting and scanning gate lines, image information signals to be sent to a source line drive circuit, and Vsync and Hsync signals for providing transfer timing thereof, and sends the signals to the panel controller 22.

The panel controller 22 sends these control signals to respective drive circuits for the gate lines, source lines and the common electrode.

Power is supplied to the respective circuit blocks through a power management 26.

In the display module 217 described above, on the basis of the image data outputted from the panel controller 22 and the timing control signals such as Vsync and Hsync, desired voltages are supplied from the gate line drive circuit 213, the source line drive circuit 212, and the common electrode drive circuit 216 to the TFT backplane 214 of the display panel 10 including the TFT backplane 214 and the display portion 215. As a result, an electrophoretic state of particles in each pixel of the display portion 215 is changed to effect gradation display.

The display apparatus of this embodiment has two display modes including a gradation display mode and a binary display mode, as described in detail later. In the case of pen input, the binary display

mode is employed. For this reason, the above described source line drive circuit 212 has an output stage capable of selecting high impedance.

Hereinbelow, the display apparatus of this embodiment will be described as an electrophoretic display apparatus. However, the display apparatus of the present invention may be any display apparatus so long as it can be driven by a voltage. Accordingly, the display apparatus may be a liquid crystal display apparatus.

It is preferable that a voltage to be applied is variable so as to permit display of an intermediary state at multiple gradation levels. The display apparatus of the present invention is applicable to a so-called memory type display apparatus capable of retaining a written display state as it is without applying a voltage to pixel after completion of writing.

Figure 3 shows a schematic view of a portion of a TFT active matrix array with 300 rows and 250 columns in this embodiment.

Referring to Figure 3, the display panel 10 described above includes gate line electrodes (scanning electrodes) 33 and source line electrodes (data electrodes) 34 arranged in a matrix. A multitude of pixels are formed at respective intersections of these electrodes 33 and 34. The display panel 10

further includes TFTs 35, pixel electrode 36, and a common electrode (COM) 37 and is connected with the gate line drive circuit 213 for driving the gate line electrodes 33 and the source line drive circuit 212 for driving the source line electrodes 34. In this embodiment, a gate line driving voltage is +20 V with respect to an on-state voltage and -20 V with respect to an off-state voltage. A frame rate is 15 Hz. Further, a source line drive voltage Vw is 0 to 15 V, and a common electrode drive voltage Vcom is 30 to -15 V.

Figures 4(a) and 4(b) are schematic views each showing one pixel portion of the electrophoretic display apparatus in this embodiment. In these figures, black electrophoretic particles 63 are negatively charged electrically. In the case where, e.g., a first electrode 37 is a common electrode and a second electrode 36 is a pixel electrode, the pixel electrode 36 is covered with the black electrophoretic particles 63 to provide a black display state as shown in Figure 4(a) when a positive(-polarity) voltage is applied to the pixel electrode 36 with respect to the common electrode 37. On the other hand, when a negative(-polarity) voltage is applied to the pixel electrode 36 with respect to the common electrode 37, as shown in Figure 4(b), the black electrophoretic particles 63 are collected to the pixel electrodes 37

each located between adjacent pixels. As a result, the pixel electrode 36 is exposed, thus providing a white pixel state.

Figure 5(a) shows a voltage-optical response (reflectance) characteristic at pixel in this embodiment.

More specifically, when an initial display state is a white state, as indicated by a solid line, the voltage-reflectance characteristic is such that the display state is the white state at a voltage of not more than 0 V and is a black state at a voltage of not less than 15 V. Further, the voltage-reflectance characteristic when the initial display state is the black state is indicated by a dashed line.

Figure 5(b) shows a voltage-response time characteristic at pixel in this embodiment.

In this case, the response time is a time from start of the response to completion thereof from the white state to the black state. As shown in Figure 5(b), it can be understood that the response characteristic is improved with an increasing applied voltage. Incidentally, in the case of effecting 16 level gradation display, all the pixels are placed in the white state and then gradation control is effected in a source line drive voltage range (0 to 15 V). At that time, the Vcom is 0 V (grounding voltage).

As described above, to the display apparatus,

the external input device 27 (the positional information input device, such as the pen input apparatus) is connected. The pen input apparatus detects a position designated by a pen and outputs the detected position as digital information. The pen input apparatus (device) may be constituted by a pen and a special-purpose tablet but may be used as a pointing device such that it is formed of a transparent member and is superposed on the display panel, and an image on the display panel is overwritten with the pen or the picture area is scanned with the pen. In the case of lamination structure, the display panel is required to permit display of line image, such as a handwritten character inputted by the pen, with no delay.

Next, the pen input from the pen input tablet 27 will be considered. When the input is performed by designating a position on the tablet with the pen, it is assumed that additional writing is effected in the displayed picture image area. In this case, rewriting of display is required only with respect to the added portion with the pen. In other words, it is also possible to retain the display state as it is at a portion other than the added portion with the pen.

When the pen input is not performed, there is no output from the pen input table 27, so that the digitizing control circuit 23 transmit information

thereon to the graphic controller 21, which selects an ordinary display mode, i.e., a mode of displaying image information of the internal memories 29 and 210 and external image information received through the communication means 24. At that time, the gate line drive circuit 213 sequentially scans selectively the gate lines of the display panel, and the source line drive circuit 212 supplies a gradation signal voltage, depending on the image information, i.e., a variable voltage in such a range that it can vary from 0 to 15 V on the black display side and from 0 to -15 V on the white display side. A reference voltage is supplied from the common electrode drive circuit 216. These voltages are applied to the TFT backplane 214 to change an electrophoretic state of the electrophoretic particles in each pixel of the display portion 215. As a result, gradation display is performed.

When the pen input is effected, positional information depending on a position designated with the pen is sent from the pen input tablet 27 to the graphic controller 21 through the digitizing control circuit 24, and is written in the SDRAM 211 as the display memory. At this time, a flag is set at an SDRAM address of the written pixel so as to show that the pen input is effected at the address.

The graphic controller 21 sends the image information of the display memory to the display panel

217 but when the flag is set, the ordinary display mode is switched to such a display mode that scanning lines including the flagged portion are scanned on a priority basis. In this display mode, a rewriting operation of only the pen input portion is performed such that only the rewritten portion of the gate lines of the display panel 10 is scanned by the graphic controller 21. In this case, a black signal is sent to a source line of pixel to be rewritten and at the same time, a source line of pixel to be held in the previous display state is placed in a high-impedance state. The detailed writing operation will be described later.

Hereinafter, such a driving method during the pen input is referred to as "partial rewriting". The partial rewriting takes only a short time required to perform rewriting by partial scanning since the number of gate lines at a portion to be rewritten is smaller than the number of all the scanning lines, i.e., gate lines even in such a display panel having a large number of scanning (gate) lines. In the pen input device, in order not to provide inconformity to a user, a trail of the pen is required to be displayed with no interval on the picture area (screen). This can be realized by the partial rewriting.

Further, drawing of black line on white background is sufficient to write the handwriting

character in the picture area by pen input, so that only rewriting of pixel into the black state is required. As a result, it is not necessary to perform halftone display. The display apparatus of this embodiment provides high-speed responsiveness in such a rewriting operation that only the black display is performed.

Next, high-voltage drive during partial rewriting binary device will be described.

In order to explain the high-voltage drive during partial rewriting binary drive pixels "a" and "b" shown in Figure 3 are considered. In this case, it is assumed that pen input is performed at pixels located at intersections of s1 and g1 (pixel "a"), s2 and g2, and s3 and g3, that the pixel "a" is a pixel to be subjected to rewriting and the pixel "b" is a pixel to be held as it is, and that, as previous writing, control of pixel at a desired gradation level (a reflectance R1 at the pixels "a" and a reflectance R2 at the pixel "b") is completed and an optical response is kept constant.

Figures 1(a) to 1(h) show drive waveforms with respect to the pixels "a" and "b" and timing charts of optical responses at the pixels "a" and "b". More specifically, Figure 1(a) is a waveform of a voltage applied to the gate electrode g1 shown in Figure 3, Figure 1(b) is a waveform of voltage applied to the

source electrode s1 shown in Figure 3, Figure 1(c) is a waveform of a voltage applied to the source electrode s2 shown in Figure 3, Figure 1(d) is a waveform of a voltage applied to the common electrode shown in Figure 3, Figure 1(e) is a waveform of an interelectrode voltage (a potential difference between the pixel electrode 36 and the common electrode 37) at the pixel "a" shown in Figure 3, Figure 1(f) is a waveform of an interelectrode voltage at the pixel "b" shown in Figure 3, Figure 1(g) is an optical response at the pixel "a" shown in Figure 3, and Figure 1(h) is an optical response at the pixel "b" shown in Figure 3.

First, the pixel "a" (pixel to be subjected to rewriting) will be described.

An interelectrode voltage Vp at the pixel "a" shown in Figure 1(e) corresponds to a difference between a voltage Vwmax of the source electrode s1, at a time t1 at which the gate electrode g1 is in an ON state, and a common electrode voltage Vcom, i.e., Vp = Vwmax - Vcom. Here, the Vwmax is set to be a maximum voltage (15 V) which can be outputted from the source line drive circuit. At that time, the common electrode voltage Vcom is -15 V (0 V at the time of ordinal multi-level gradation display). Accordingly, it becomes possible to apply a larger voltage than that in the case of the ordinary multi-level gradation display by Vcom (-15 V). As a result, high-voltage

drive becomes possible and response at the pixel "a" is completed in a short time.

Next, the pixel "b" (pixel to be held as it is) will be described.

Ordinarily, an interelectrode voltage at the pixel "b" shown in Figure 1(f) corresponds to a difference between a voltage of the source electrode s2, at a time t1 at which the gate electrode g1 is in an ON state, and a voltage of the common electrode. IN this case, however, the source electrode s2 is in a high-impedance state as shown in Figure 1(c). Accordingly, there is no potential difference between the pixel electrode and the common electrode at the pixel "b" so that the interelectrode voltage at the pixel "b" is not changed irrespective of the Vcom value. In other words, at the pixel "b", the display state can be held as it is.

After the black is written with respect to the scanning line g1 by the above described drive, at a time t2, the scanning line g2 is selected and a voltage is applied similarly thereto. Thereafter, in a similar manner, only a selected scanning line is sequentially scanned.

As described above, the high-voltage drive during the partial rewriting binary drive is realized. Further, during this drive, it is also possible to scan the entire picture area but it becomes possible

to realize high-speed display response by scanning only scanning lines along pixel(s) to be subjected to rewriting.

According t this embodiment, the response performance of low response speed display device can be improved to permit pen input with no stress.

(Embodiment 2)

In this embodiment, the display apparatus of the present invention is applied to white/black binary display, and the display apparatus identical to that used in Embodiment 1 is used.

The pen input device is required to have a function of erasing an incorrectly-inputted line or drawing a trail of the pen by inverting white and black states of line even at a black background portion. In this case, it is necessary to effect white writing in pixel in addition to the black writing described in Embodiment 1. Further, when a part of an image displayed on the picture area (screen) is moved by dragging with the pen, white is written at a pixel where the image is completely moved as a background picture area. The display apparatus in this embodiment performs display response at high speed during white/black binary display, whereby it is also possible to effect binary motion picture display.

In order to explain display by binary half-toning (gradation representation), pixels "a" and

"b" shown in Figure 3 are considered. In this case, it is assumed that black is displayed at pixels located at intersections of s1 and g1 (pixel "a"), s2 and g2, and s3 and g3, that white is displayed at other pixels including the pixel "b", and that, an optical response is kept constant at pixel(s) where control thereof at a desired gradation level is completed.

Figures 6(a) to 1(h) show drive waveforms with respect to the pixels "a" and "b" and timing charts of optical responses at the pixels "a" and "b". More specifically, Figure 6(a) is a waveform of a voltage applied to the gate electrode g1 shown in Figure 3, Figure 6(b) is a waveform of voltage applied to the source electrode s1 shown in Figure 3, Figure 6(c) is a waveform of a voltage applied to the source electrode s2 shown in Figure 3, Figure 6(d) is a waveform of a voltage applied to the common electrode shown in Figure 3, Figure 6(e) is a waveform of an interelectrode voltage at the pixel "a" shown in Figure 3, Figure 6(f) is a waveform of an interelectrode voltage at the pixel "b" shown in Figure 3, Figure 6(g) is an optical response at the pixel "a" shown in Figure 3, and Figure 6(h) is an optical response at the pixel "b" shown in Figure 3. As shown in these figures, when the motion picture display is performed based on white/black two values, an image is formed in one frame divided into two

fields. Hereinbelow, a driving method in this embodiment will be described in detail.

First, field 1 will be described. The pixel "a" (pixel for displaying black) will be described. An interelectrode voltage Vblack at the pixel "a" shown in Figure 6(e) corresponds to a difference between a voltage Vwmax of the source electrode s1, at a time T11 at which the gate electrode g1 is in an ON state, and a common electrode voltage Vcom, i.e., Vblack = Vwmax - Vcom. Here, the Vwmax is set to be a maximum voltage (15 V) which can be outputted from the source line drive circuit. Accordingly, it becomes possible to apply a larger voltage than that in the case of the ordinary multi-level gradation display by Vcom (-15 V). As a result, high-voltage drive becomes possible and response at the pixel "a" is completed in a short time.

Next, the pixel "b" (pixel for displaying white) will be described. An interelectrode voltage at the pixel "b" shown in Figure 6(f) corresponds to a difference between a voltage of the source electrode s2, at a time T11 at which the gate electrode g1 is in an ON state, and a voltage of the common electrode. IN this case, however, the source electrode s2 is in a high-impedance state as shown in Figure 6(c). Accordingly, there is no potential difference between the pixel electrode and the common electrode at the pixel "b" so that the interelectrode voltage at the

pixel "b" is not changed irrespective of the Vcom value. In other words, at the pixel "b", the display state can be held as it is.

Next, field 2 will be described.

The pixel "a" (pixel for displaying black) will be described. As shown in Figure 6(b), the source electrode s1 is in a high-impedance state at a time T21 at which the gate electrode g1 is in an ON state. Accordingly, there is no potential difference between the pixel electrode and the common electrode at the pixel "a" so that the interelectrode voltage at the pixel "a" is not changed irrespective of the Vcom value. In other words, at the pixel "a", the black display state can be held as it is.

First, the pixel "b" (pixel for displaying white) will be described. An interelectrode voltage Vwhite at the pixel "b" shown in Figure 6(e) corresponds to a difference between a voltage Vwmin of the source electrode s2, at a time T21 at which the gate electrode g1 is in an ON state, and a common electrode voltage Vcom2, i.e., Vwhite = Vwmin - Vcom2. Here, the Vwmin is set to be a minimum voltage (0 V) which can be outputted from the source line drive circuit. Accordingly, it becomes possible to apply a larger voltage than that in the case of the ordinary multi-level gradation display by Vcom2 (30 V). As a result, high-voltage drive becomes possible and

response at the pixel "b" is completed in a short time.

By the above described driving method, a response performance of low response speed display device is improved to permit good motion picture display.

(Embodiment 3)

In this embodiment, a display apparatus has 16 gradation level display mode and a binary display mode and uses the binary display mode during pen input. A source line drive circuit has selectable output stages including a D/A converter output stage and an analog switch output stage. In the binary display mode, the analog switch output stage is employed. In this embodiment, the display apparatus is identical to that used in Embodiment 1 except for the source line drive circuit described above.

In the case of the 16 gradation level display mode, the D/A converter output stage is employed and a drive voltage has a maximum of 15 V and a minimum of 0 V. On the other hand, the analog switch output stage is employed when the binary display is performed, and a drive voltage is selectable between 30 V (ON state) and 0 V (OFF state) by switching.

In order to explain display by binary half-toning (gradation representation), pixels "a" and "b" shown in Figure 3 are considered. In this case, it is assumed that black is displayed at pixels located

at intersections of s1 and g1 (pixel "a"), s2 and g2, and s3 and g3, that white is displayed at other pixels including the pixel "b", and that, an optical response is kept constant at pixel(s) where control thereof at a desired gradation level is completed.

When the pen input is performed after completion of control of the pixels at a desired gradation level, e.g., in the analog switch mode, an ON voltage (30 V) is applied to the source electrode of the pixel "a" and an OFF voltage (0 V) is applied to the source electrode of the pixels "b". As a result, it becomes possible to apply to the pixel "a" a voltage higher than that in the case of the 16 gradation level display mode by 15 V. Thus, response at the pixel "a" is completed in a short time. To the pixel "b", the voltage of 0 V is applied but a resultant optical response level is kept constant based on a holding characteristic of the electrophoretic display device.

According to this embodiment, a response performance of low response speed display device is improved to permit pen input with no stress. Further, during the pen input, it is possible to realize a small-scale circuit by use of the analog switch output stage compared with such a circuit that the same level voltage is applied for drive by use of the D/A converter.

In the above described embodiments, the display apparatus of the present invention is described with respect to the electrophoretic display apparatus as an example but may be applicable to liquid crystal display apparatuses using a polymer network liquid crystal, a ferroelectric liquid crystal, etc. Further, the display apparatus of the present invention may also be applicable to both the horizontal movement type electrophoretic display apparatus and the vertical movement type electro-phoretic display apparatus. In the electrophoretic display apparatus, the electrophoretic particles and a dispersion medium may be encapsuled in a multitute of microcapsules.

[INDUSTRIAL APPLICABILITY]

As described hereinabove, according to the display apparatus of the present invention, in the case where a display state in a display panel is rewritten by binary gradation representation, it becomes possible to realize high-speed responsiveness by effecting drive at a voltage higher than a maximum drive voltage in multi-level display. Further, it is possible to realize a small packaging scale of a peripheral circuit and a reduction in production cost.

CLAIMS

1. A display apparatus, comprising:

a display panel including pixels arranged in a matrix,

pixel electrodes provided to the pixels, respectively, and a common electrode provided commonly to the pixels,

scanning lines and signal lines for supplying a voltage to said pixel electrodes,

a drive circuit connected to said common electrode, said scanning lines, and said signal lines, and

a control circuit for providing a signal to said drive circuit,

wherein said control circuit selectively switches a display drive mode in which said display apparatus displays an image on said display panel through sequential scanning of said scanning lines and application of a variable voltage to pixels via said signal lines by said drive circuit and a rewriting drive mode in which said display apparatus rewrites a part of pixels into black or white through application of a voltage, which is higher than a range of the variable voltage, to the part of pixels on a scanning line selected by said drive circuit.

2. An apparatus according to Claim 1, wherein said drive circuit selectively scans only a part of the scanning lines in the rewriting drive mode.

3. An apparatus according to Claim 1 or 2, wherein in the display drive mode, said drive circuit supplies a variable voltage to said pixel electrodes and a reference voltage to said common electrode, and in the rewriting drive mode, said drive circuit supplies the voltage higher than the range of the variable voltage to a pixel electrode of pixels to be rewritten, places a pixel electrode not to be rewritten in a high-impedance state, and supplies to said common electrode a voltage which is shifted from the reference voltage to an opposite-polarity side of the voltage supplied to the pixel electrode of pixels to be rewritten.

4. An apparatus according to any one of Claims 1 - 3, wherein said display apparatus further comprises an external input device, and when said display apparatus receives display information from a device other than the external input device, said control circuit selects the display drive mode to execute display of the display information on said display panel, and when said display apparatus

received display information from the external input device, said control circuit selects the rewriting drive mode to execute display of the display information received from the external input device.

5. An apparatus according to Claim 4, wherein the external input device is a position information input device superposed on said display panel.

6. An apparatus according to Claim 4 or 5, wherein the external input device is a pen input device or a handwriting input device.

7. An apparatus according to any one of Claims 1 - 6, wherein said display apparatus is an electrophoretic display apparatus.

8. An apparatus according to any one of Claims 1 - 6, wherein said display apparatus is a liquid crystal display apparatus.

9. An input apparatus, comprising:

a display panel including pixels arranged in a matrix,

pixel electrodes provided to the pixels, respectively, and a common electrode provided commonly to the pixels,

scanning lines and signal lines for supplying a voltage to said pixel electrodes,

a drive circuit connected to said common electrode, said scanning lines, and said signal lines,

a control circuit for providing a signal to said drive circuit,

a position detection device for detecting a position designated by a positioning member and outputting information on the detected position,

wherein when there is no output of said position detection device, said control circuit selects a display drive mode in which a gradation image is displayed on said display panel and said drive circuit applies a variable voltage to pixels through said scanning and data lines to display the gradation image on said display panel, and when there is an output of said position detection device, said control circuit selects a rewriting drive mode in which a part of pixels of said display panel is rewritten into black or white and said drive circuit scans a part of said scanning lines and applies a voltage, which is higher than a range of said variable voltage, to a part of pixels to rewrite the part of pixels corresponding to the position designated by the pointing member.

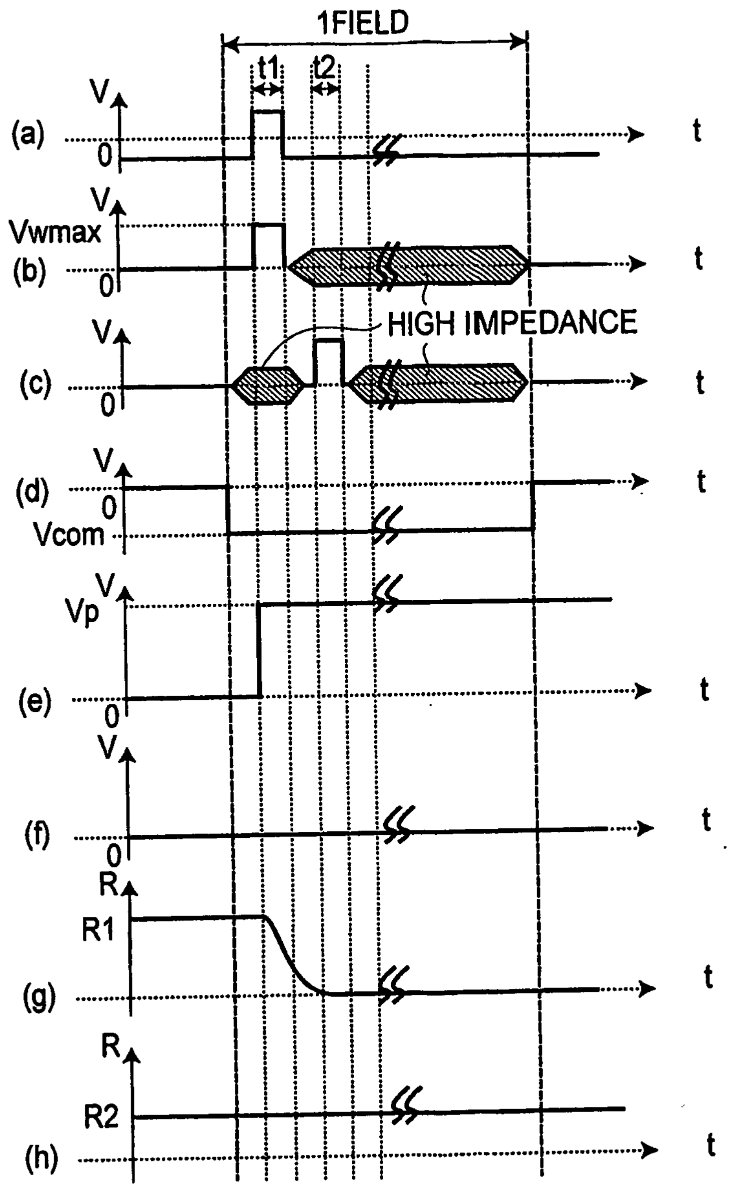
1FIELD
t1
t2
V
(a)
0
t
V
Vwmax
(b)
0
t
HIGH IMPEDANCE
V
(c)
0
t
V
(d)
0
Vcom
t
Vp
V
(e)
0
t
V
(f)
0
t
R
R1
(g)
t
R
R2
(h)
t

FIG.1

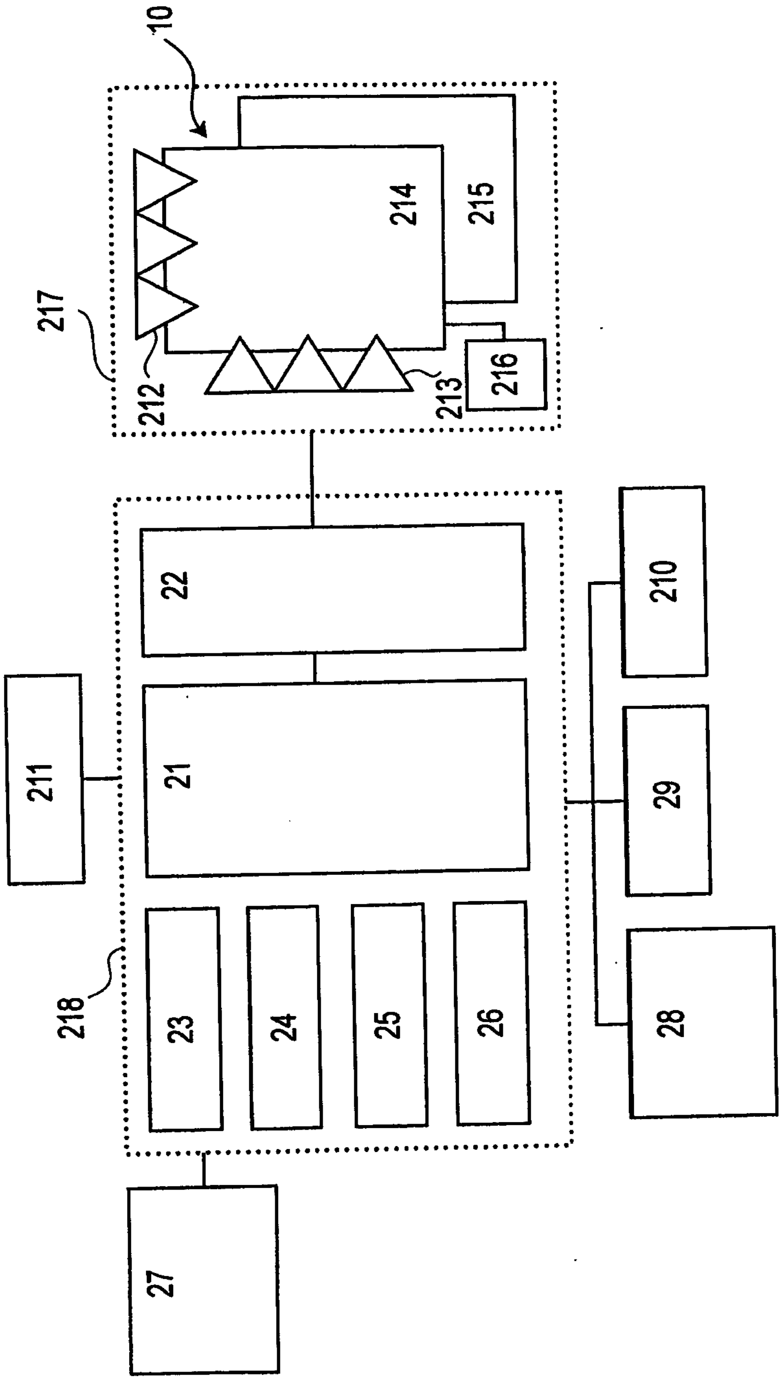

FIG.2

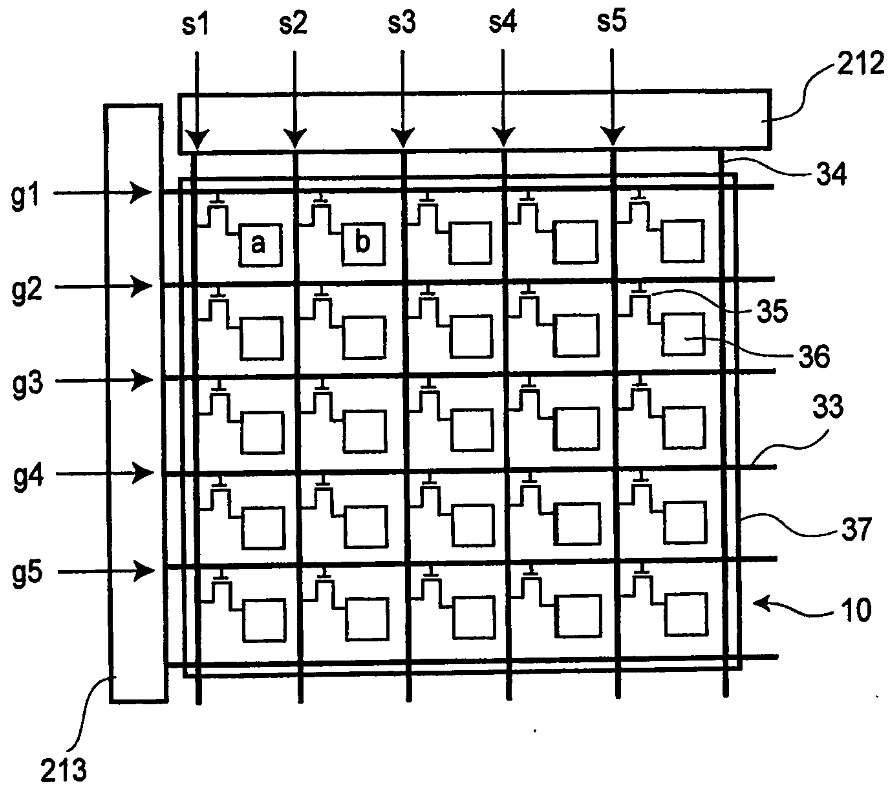

FIG.3

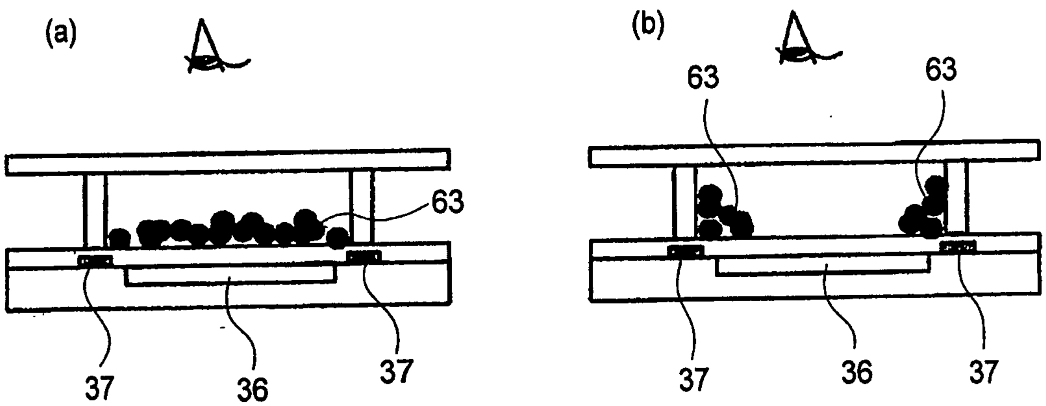

FIG.4

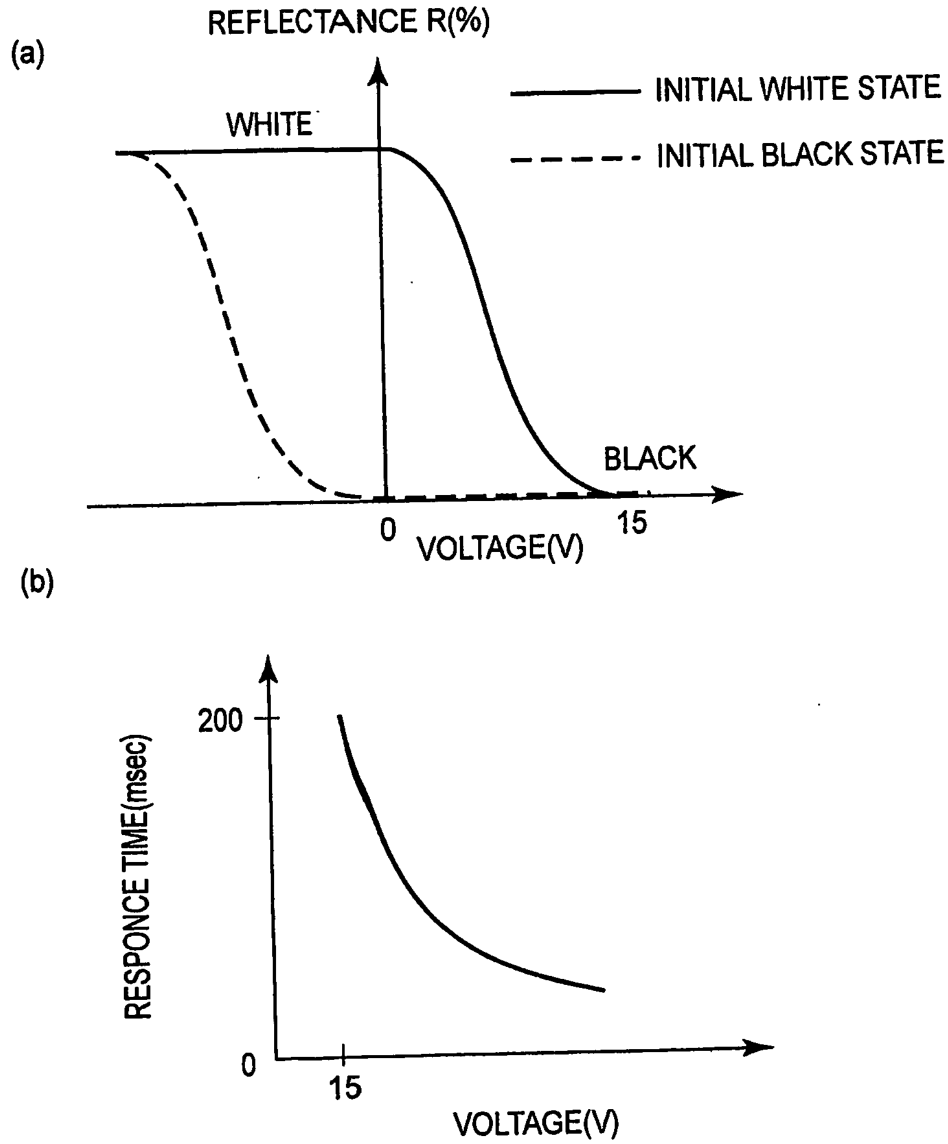
(a)
REFLECTANCE R(%)
INITIAL WHITE STATE
INITIAL BLACK STATE
WHITE
BLACK
0
15
VOLTAGE(V)
(b)
200
RESPONCE TIME(msec)
0
15
VOLTAGE(V)

FIG.5

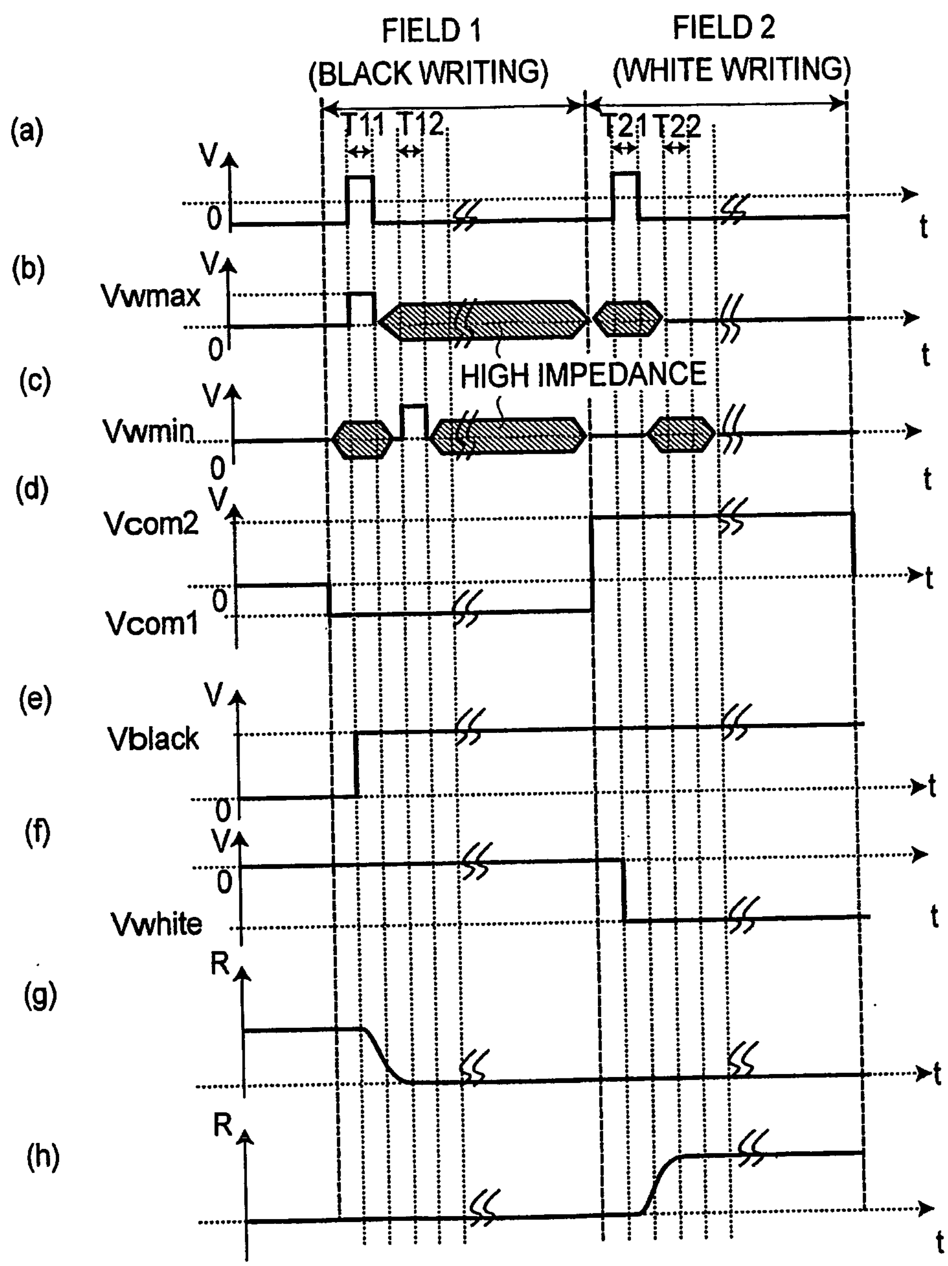
FIELD 1
(BLACK WRITING)
FIELD 2
(WHITE WRITING)
T11
T12
T21
T22
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
V
0
t
Vwmax
Vwmin
HIGH IMPEDANCE
Vcom2
Vcom1
Vblack
Vwhite
R

FIG.6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/JP2004/018433

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G09G3/34 G06F3/033 G09G3/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06F G09G G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 March 2005	31/03/2005

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/JP2004/018433

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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		WO 03079176 A2	25-09-2003

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